SURFACE TEXTURES OF CALCAREOUS FORAMINIFERIDS

by J. W. MURRAY *and* C. A. WRIGHT

ABSTRACT. A comparison is made between the surface appearance of fresh calcareous foraminiferid tests, those etched artificially, and those found in fossil representatives from the Hampshire Basin. It is concluded that most fossil foraminiferids show some post-mortem etching of the test surface.

THE texture of the wall surface and the relative size of the pores have been used as specific characters in taxonomic studies of foraminiferids based on examination under the light microscope. Recent descriptions of the ultrastructure of the calcareous foraminiferid wall (Hay, Towe, and Wright 1963, Lynts and Pfister 1967, Towe and Cifelli 1967) have been illustrated by excellent electron photomicrographs of surface and internal features. With the introduction of the scanning electron microscope to the study of foraminiferids much more information on textures and structures will become available.

The preparation of material for examination in the two types of electron microscope is quite different. For the transmission electron microscope the material is replicated, usually with carbon, and it is the replica which is examined. The scanning electron microscope can be used to examine specimens directly, providing they have a conducting layer on the surface. Foraminiferids are usually coated with a gold–palladium mixture but other metals such as gold or aluminium have also been used with success. The disadvantage of the metallic coating is that it obscures detail finer than its own thickness. Hay and Sandberg (1967) state the resolution of the transmission microscope to be 5 Å and that of the scanning microscope to be 200 Å. However, this disadvantage is offset by the great depth of field of the scanning microscope.

Routine examination of Tertiary and Recent foraminiferids from the Hampshire Basin and Western Approaches at magnifications of ×20 to ×6000 has provided a large amount of information on the texture of foraminiferid walls. Magnifications of up to ×20 000 have been used where necessary. Altogether some 1200 photomicrographs have been taken to date.

When viewing a wall texture in detail it is important to establish whether the structures observed are primary or secondary. Two processes can lead to post-mortem changes in the surface texture: physical abrasion with sedimentary particles, and chemical etching of those walls which are calcareous. These processes may operate singly or together. The present discussion is concerned only with textures resulting from chemical etching.

A short note by Murray (1967) described how hyaline calcareous foraminiferids which appeared transparent when fresh could be made opaque by etching. In the examples described below, species of Recent foraminiferids have been studied in a fresh unetched condition and compared with forms which have been artificially etched in EDTA and with fossil forms which show comparable textures.

[Palaeontology, Vol. 13, Part 2, 1970, pp. 184–7, pl. 37–39.]

Examples

Protelphidium anglicum Murray (1965) has a radiate, perforate, calcite test wall. In living individuals the outer test surface is smooth and shows irregularly distributed circular pores about 1–1·5μ in diameter (Pl. 37, fig. 2). When such a specimen is etched for 2–3 minutes in 5% EDTA, the wall becomes white and opaque (Murray 1967). Under high magnification the pores are seen to have become polygonal and often they are located near the centre of a polygonal 'crystal' (Pl. 37, figs. 3–5). Occasionally the pore is eccentric or even peripheral to the 'crystal'. The 'crystals' have sutured contacts with one another and have an uneven etched surface. This may indicate that they are composed of bundles of fibres (R. Bradshaw, University of Bristol, pers. comm.). These may be analogous to the plate-like units observed in the radial wall of *Ammonia beccarii* (Linné) by Towe and Cifelli (1967).

The same type of etched surface has been seen in *Protelphidium* sp. from Oligocene rocks (Middle Headon Beds) of the Isle of Wight, England (Pl. 37, fig. 5).

Nummulites rectus Curry from the Lower Barton shows the same type of etched surface. Plate 38, figs. 1, 2 show these textures on the inside of the chamber wall in a broken form. The same polygonal 'crystals' can be seen with sutured contacts and a central pore. In the fossil forms, however, the 'crystal' is composed of radiating 'blocks', the number present depending on the stage to which the etching has exposed the divisions between them. Eight to ten 'blocks' are present surrounding the pore and each of these has a rough texture exhibiting the same bundle-of-fibre structure. Between the pores, 'bundles' of 'crystals' fill in the spaces, groups of 'bundles' being separated by sutured contacts.

In the umbilical region of modern examples of *Protelphidium anglicum* there are no pores in the wall. Etching does not reveal crystal boundaries although the previously smooth shell becomes pitted (Pl. 37, fig. 3).

Cibicides lobatulus (Walker and Jacob) also has a radiate calcite test wall. In fresh specimens the wall is smooth (Pl. 38, figs. 3, 4) but in specimens etched in 5% EDTA the wall becomes irregularly pitted. In this species the pores are relatively large (6–7μ in diameter) and it seems probable that the component calcite crystals of the wall surround each pore. Etching leads to pore enlargement.

The same etched surface texture has been seen in fossil forms of this species from the Upper Barton Beds of Hampshire. These forms also display large pores with complex layered internal structures separated by etched wall with irregular pitted texture best displayed in the apertural region where the pores are less abundant (Pl. 38, fig. 6).

The wall structure of *Ammonia beccarii* (Linné) was described in detail by Towe and Cifelli (1967). The greater part of the wall is made up of plate-like calcite units which are very much smaller than the wall pores. When the surface is etched, the pores are enlarged and the surface becomes uneven (Pl. 39, figs. 1, 2). Etching preferentially attacks the pores because of the large surface area of their walls.

In fossil forms of *Nonion laeve* (d'Orbigny), the effects of abrasion on the high points of the chambers can be seen. This abrasion aids the chemical etching of the test by destroying the original smooth surface. In this form (Pl. 38, fig. 7) the chamber is very severely etched to produce a rough and pitted texture compared with the smooth wall visible along the suture and on the sutural processes. The chamber wall immediately adjacent to the suture is also smooth but the wall becomes pitted on the elevated part of the chamber.

Early stages in the etching process have been studied in fossil forms of *Melonis affine* (Reuss) which has a granular perforate calcite test wall and an open umbilicus. The wall is normally smooth and finely perforate but in some fossil forms this smooth wall is broken up by a series of interlocking cracks with a pore at the centre of each system. These cracks appear to be the first stages in the production of the sutured contacts between the 'crystals' (Pl. 39, figs. 3–5).

The common Recent miliolid *Quinqueloculina seminulum* (Linné) normally has an opaque white, imperforate test in which the surface has a porcelain-like glaze. The wall structure in general is described as 'porcellaneous'. Under a magnification of ×20 000, the 'tile-roof' pattern of calcite crystals forming the surface glaze may just be made out (see Hay, Towe, and Wright 1963 and Towe and Cifelli 1967; also the 'pavement-like pattern' of Lynts and Pfister 1967). When the wall is etched in 5% EDTA, the 'tile-roof' glaze can be readily seen and beneath it the very disorganized layers of calcite rods are revealed (Pl. 39, figs. 6, 7). The 'roof-tile' crystals average 2μ in length

---

EXPLANATION OF PLATE 37

Figs. 1–5. *Protelphidium anglicum* Murray; Recent, Christchurch Harbour, England. 1, Lateral view of specimen with attached turbellarian egg case; maximum diameter of specimen 533μ; ×105. 2, Details of smooth wall with pores averaging 1–1·5μ in diameter; ×5600. 3, Chamber wall etched in 5% EDTA showing 'crystals' with pores and an underlying layer; the umbilical region in the upper part of the photograph is only slightly pitted; ×2100. 4, Strongly etched chamber wall (using 5% EDTA) showing layered structure, 'crystals' and pores; ×1950. 5, Enlargement of fig. 4. Note sutured boundaries between 'crystals' and the polygonal pores; ×5900.

Fig. 6. *Protelphidium* sp.; Middle Headon Beds (Oligocene), Headon Hill, Isle of Wight. Naturally etched wall showing many similarities with figs. 3, 4 and 5; ×1500.

EXPLANATION OF PLATE 38

Figs. 1, 2. *Nummulites rectus* Curry; Lower Barton Beds, Becton Bunny, Hampshire. 1, View of inside of chamber wall to show etched 'crystals' composed of 'blocks', each 'crystal' being pierced by a pore (diameter 0·5–1μ); ×2250. 2, Enlargement of part of fig. 1; ×5550.

Figs. 3–5. *Cibicides lobatulus* (Walker and Jacob); Recent, Western Approaches. 3, View of spiral side to show the coarsely perforate test; ×126. 4, Smooth, unetched wall with pores (diameter 6–7μ); ×1050. 5, Wall etched with 5% EDTA; ×2170.

Fig. 6. *Cibicides lobatulus* (Walker and Jacob); Upper Barton Beds (Zone H), Barton Cliff, Hampshire. Natural etched wall; ×1650.

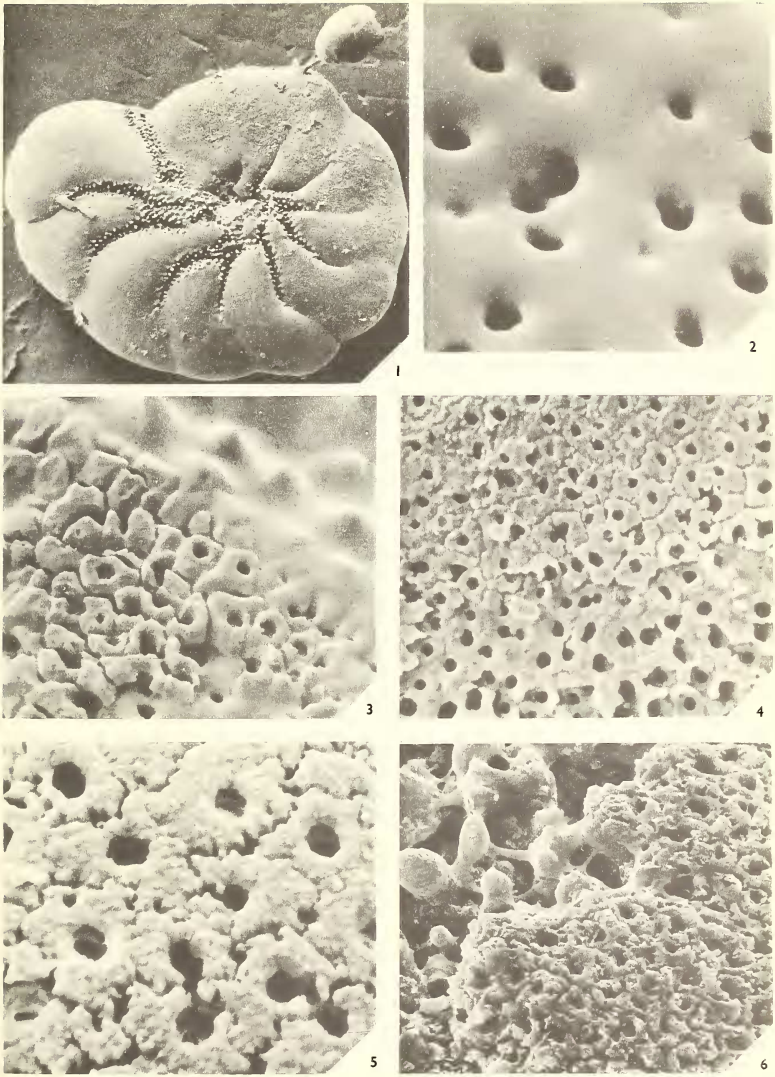
Fig. 7. *Nonion laeve* (d'Orbigny); Lower Barton Beds, Becton Bunny, Hampshire. View of smooth unetched suture with adjacent chamber walls etched; ×2000.

EXPLANATION OF PLATE 39

Figs. 1, 2. *Ammonia beccarii* (Linné), Recent, Western Approaches. 1, Dorsal view of complete test etched in 5% EDTA; note the pore enlargement; ×154. 2, Details of pores enlarged by etching; ×1536.

Figs. 3–5. *Melonis affine* (Reuss); Middle Barton Beds (Zone F), Barton Cliff, Hampshire. 3, General view; ×210. 4, Incipient etching of the granular wall surface; ×1130. 5, Enlargement of fig. 4; ×2325.

Figs. 6, 7. *Quinqueloculina seminulum* (Linné); Recent, Western Approaches. 6, Wall etched in 5% EDTA to reveal the surface 'roof-tile' layer of rectangular crystals and the underlying layer of randomly oriented rods; ×4800. 7, Details of the randomly oriented rods; ×9350.



MURRAY and WRIGHT, Surface textures of calcareous foraminiferids